

What is claimed is:

CLAIMS

5 1. A haptic feedback mouse device for providing haptic sensations to a user, said haptic feedback mouse device comprising:

 a housing physically contacted by said user and moveable in an x-y plane;

 a sensor coupled to said housing and operative to output a sensor signal indicative of said movement in said x-y plane;

 an actuator coupled to said housing; and

10 an eccentric mass coupled to said actuator, wherein said eccentric mass can be rotated by said actuator, and wherein said rotation of said eccentric mass causes inertial haptic sensations to be output on said housing and felt by said user.

 2. A haptic feedback mouse device as recited in claim 1 wherein said actuator rotates said eccentric mass approximately in an x-z plane, a y-z plane, or a combination thereof.

15 3. A haptic feedback mouse device as recited in claim 1 wherein said actuator rotates said eccentric mass approximately in an x-y plane.

 4. A haptic feedback mouse device as recited in claim 1 wherein said inertial force is a pulse correlated with the interaction of a user-controlled cursor with a graphical object displayed in a graphical user interface.

20 5. A haptic feedback mouse device as recited in claim 4 wherein said pulse is output with a magnitude dependent on a characteristic of said graphical object with which said cursor interacts.

 6. A haptic feedback mouse device as recited in claim 1 wherein said force is included in a force sensation, said force sensation being one of a pulse, vibration, and texture force.

25 7. A haptic feedback mouse device as recited in claim 1 further comprising a microprocessor, separate from said host computer, coupled to said sensor and to said actuator, said microprocessor operative to receive host commands from said host computer and output force signals to said actuator for controlling said inertial force, and operative to receive said

sensor signal from said sensor, process said sensor signal, and report locative data to said host computer derived from said sensor signal and indicative of said movement of said mouse.

8. A haptic feedback mouse device as recited in claim 1 wherein said sensor includes a ball that frictionally contacts a surface on which said housing is moved by said user.

5 9. A haptic feedback mouse device as recited in claim 1 wherein said sensor includes an optical sensor that detects motion of a surface on which said housing is moved relative to said housing of said mouse.

10 10. A haptic feedback mouse device as recited in claim 1 wherein said actuator is controlled harmonically with a drive signal input to rotate said eccentric mass in two directions and produce an inertial vibration.

11. A haptic feedback device for providing haptic sensations to a user, said haptic feedback device comprising:

15 a housing physically contacted by said user, wherein said housing includes a movable portion and a base portion, wherein said movable portion is movable with respect to said base portion, and wherein said moveable portion includes a magnet;

an actuator coupled to said housing; and

20 an eccentric mass coupled to said actuator, wherein said eccentric mass can be rotated by said actuator, and wherein a magnetic interaction between said eccentric mass and said magnet causes an inertial haptic sensation to be output on said movable portion of said housing and felt by said user when said user contacts said movable portion, said inertial haptic sensation influenced by the position of said eccentric mass.

25 12. A haptic feedback device as recited in claim 11 wherein said movable portion is a button on said haptic feedback device, and said base portion is a remaining portion of said housing, said button operative to close a switch when pressed by said user, said switch outputting a button signal.

13. A haptic feedback device as recited in claim 11 wherein said haptic feedback device is a mouse and wherein said housing is movable in an x-y plane by said user.

14. A haptic feedback device as recited in claim 11 wherein said eccentric mass is made of a material that interacts magnetically with said magnet.

15. A haptic feedback device as recited in claim 14 wherein said eccentric mass is made of iron or steel.

5 16. A haptic feedback device as recited in claim 15 wherein said eccentric mass is made of a permanently-magnetic material.

17. A haptic feedback device as recited in claim 11 wherein said eccentric mass is rotated in a x-z plane or a y-z plane.

10 18. A haptic feedback device as recited in claim 11 wherein said haptic feedback device includes an inertial mode, wherein said eccentric mass is rotated to provide inertial haptic sensations to said housing caused by said rotation, and wherein said haptic feedback device includes a kinesthetic mode, wherein said eccentric mass is rotated to a particular position to provide a force on said movable portion based on said position of said eccentric mass.

15 19. A haptic feedback device as recited in claim 18 wherein said eccentric mass is controlled to provide a spring force on said movable portion.

20. A haptic feedback device as recited in claim 18 wherein said eccentric mass is controlled to provide a resistance force on said movable portion.

21. A haptic feedback device as recited in claim 11 wherein said haptic feedback device is a gamepad.

20 22. A haptic feedback device for providing haptic sensations to a user, said haptic feedback device comprising:

25 a housing physically contacted by said user, wherein said housing includes a movable portion and a base portion, wherein said movable portion is movable with respect to said base portion;

an actuator coupled to said housing or to said movable portion;

a mass coupled to said actuator, wherein said mass can be rotated by said actuator; and

a stop member coupled to said movable portion if said actuator is coupled to said housing, or to said housing if said actuator is coupled to said movable portion, wherein said stop

member is positioned at least partially in a path of rotation of said mass, and wherein said mass is moved against said stop to produce haptic sensations on said movable portion that are felt by said user contacting said movable portion.

5 23. A haptic feedback device as recited in claim 22 wherein said mass is an eccentric mass.

 24. A haptic feedback device as recited in claim 22 wherein said haptic feedback device is a mouse.

10 25. A haptic feedback device as recited in claim 22 further comprising a sensor coupled to said housing and operative to output a sensor signal indicative of movement of said housing in an x-y plane.

 26. A haptic feedback device as recited in claim 22 wherein said movable portion is a button of said device, said button operative to close a switch when pressed by said user, said switch outputting a button signal.

15 27. A haptic feedback device as recited in claim 24 wherein said actuator is coupled to said movable portion and wherein said stop member is coupled to said housing.

20 28. A haptic feedback device as recited in claim 22 wherein said stop member is a first stop member, and further comprising a second stop member coupled to said same movable portion or said housing to which said first stop member is coupled, wherein said first and second stop members define a rotatable range for said mass.

 29. A haptic feedback device as recited in claim 22 wherein said actuator is controlled harmonically with a drive signal input to rotate said eccentric mass in two directions and produce a vibration.

25 30. A haptic feedback device as recited in claim 22 wherein said haptic feedback device includes an inertial mode, wherein said eccentric mass is rotated harmonically away from said stop to provide inertial haptic sensations to said housing caused by said rotation.

 31. A haptic feedback device as recited in claim 22 wherein said haptic feedback device includes a kinesthetic mode, wherein said eccentric mass is rotated against said stop member to output a force on said movable portion.

32. A haptic feedback device as recited in claim 22 wherein a vibration is induced in said housing by impacting said mass against said stop periodically.

5 33. A haptic feedback mouse device for providing haptic sensations to a user, said haptic feedback mouse device comprising:

a device housing physically contacted by said user and movable in an x-y plane, wherein said device housing includes a movable portion and a main housing portion, wherein said movable portion is movable with respect to said main housing portion;

10 a moving magnet actuator having an actuator housing coupled to said device housing and a moving magnet coupled to said movable portion; and

a sensor coupled to said housing and operative to output a sensor signal indicative of said movement in said x-y plane.

15 34. A haptic feedback mouse device as recited in claim 33 wherein said movable portion includes a button of said mouse device, said button operative to close a switch when pressed by said user, said switch outputting a button signal.

35. A haptic feedback mouse device as recited in claim 34 further comprising a physical spring that biases said button near to a center of a degree of freedom of said button.

20 36. A haptic feedback mouse device as recited in claim 34 wherein said haptic feedback mouse is in communication with a host computer, said host computer displaying a graphical environments including a hierarchy of graphical objects, wherein said user can select one of said graphical objects in said hierarchy by moving said movable portion, wherein a haptic sensation indicates to said user a selection of each of said graphical objects in said hierarchy.

25 37. A haptic feedback mouse device as recited in claim 36 wherein said graphical objects in said hierarchy are windows, each of said windows provided above or below another window in said hierarchy.

38. A haptic feedback mouse device as recited in claim 37 wherein motion of said movable portion causes a selected graphical object to be moved within said hierarchy.

39. A haptic feedback mouse device for providing haptic sensations to a user, said haptic feedback mouse device comprising:

a device housing physically contacted by said user and movable in an x-y plane, wherein said device housing includes a movable portion and a main portion, wherein at least part of said movable portion is positioned on a side of said housing and is movable with respect to said main portion;

a linear actuator having an actuator housing coupled to said device housing and an actuated portion coupled to said movable portion, wherein said linear actuator moves said movable portion of said device housing linearly away from said main portion of said housing when controlled with a control signal, thereby providing a haptic sensation to a user contacting said movable portion; and

a sensor coupled to said housing and operative to output a sensor signal indicative of said movement in said x-y plane.

40. A haptic feedback mouse device as recited in claim 39 wherein said movable portion engages a thumb of said user in normal operation of said mouse device.

41. A haptic feedback mouse device as recited in claim 39 wherein said movable portion is a first movable portion, and wherein said device housing includes a second movable portion, wherein at least part of said second movable portion is movable with respect to said main portion, and wherein said second movable portion is moved by a second linear actuator to provide a haptic sensation to said user contacting said second movable portion.

42. A haptic feedback mouse device as recited in claim 41 wherein said first movable portion outputs haptic sensations applicable for an x-axis of said mouse device, and said second movable portion outputs haptic sensations applicable for a y-axis of said mouse device.

43. A haptic feedback mouse device as recited in claim 39 wherein said haptic sensation is a pulse correlated with the interaction of a user-controlled cursor with a graphical object displayed in a graphical user interface.

44. A haptic feedback mouse device as recited in claim 39 wherein said haptic sensation is one of a pulse, vibration, and texture force.

45. A haptic feedback mouse device as recited in claim 39 further comprising a microprocessor coupled to said sensor and to said actuator, said microprocessor operative to receive host commands from a host computer in communication with said mouse device, operative to output force signals to said actuator for controlling said haptic sensation, and
- 5 operative to receive said sensor signal from said sensor, process said sensor signal, and report locative data to said host computer derived from said sensor signal and indicative of said movement of said device housing.